The psychological wellbeing outcomes of nonpharmacological interventions for older persons with insomnia symptoms: a systematic review and meta-analysis

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The Psychological Wellbeing Outcomes of Nonpharmacological Interventions for Older Persons with Insomnia Symptoms: A Systematic Review and Meta-Analysis

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Summary

Nonpharmacological treatment of insomnia in older persons has been associated with reduced insomnia symptoms and increased psychological wellbeing. This systematic review and meta-analysis examined whether nonpharmacological interventions can promote wellbeing indicators in older persons who experience insomnia symptoms and investigated the components of these interventions. Twenty studies met inclusion criteria. Psychological wellbeing outcomes included symptoms of depression, anxiety, mental health-related quality of life, and fatigue. Interventions significantly reduced depression and fatigue symptoms in most of the studies that included these outcomes. Findings of our qualitative analysis suggest that mindfulness-based interventions in particularcan potentially reduce depression symptoms in older persons with insomnia symptoms. Meta-analyses of studies that included psychological wellbeing outcomes showed small-medium weighted mean effects indicating reductions in symptoms of depression, anxiety, and fatigue. The results suggest that nonpharmacological interventions for older persons with insomnia symptoms can potentially reduce depression and fatigue symptoms and highlight interventions that may be particularly valuable for this purpose.

Keywords: anxiety; depression; fatigue; insomnia, meta-analysis, nonpharmacological interventions, older persons, psychological wellbeing, systematic review

List of abbreviations[1]

[1] BT behavioural therapy; CBT-I cognitive behavioural therapy for insomnia; CT cognitive therapy; HRQoL health-related quality of life; MBI mindfulness-based intervention; MBT-I mindfulness-based therapy for insomnia; RoB risk of bias

Insomnia has been defined as the experience of difficulties with falling asleep or staying asleep, sleep length, quality, or consolidation leading to daytime impairment despite sufficient opportunity for sleep [1]. With increasing age, insomnia symptoms' prevalence [2] and severity [3] increases. Insomnia symptoms are often prevalent in over 40% of older adults [4] and have been associated with a host of adverse psychological wellbeing outcomes including depression and anxiety symptoms [5, 6]. The severity of insomnia symptoms has been associated with decreased life satisfaction, nervousness, and loneliness in older persons [7]. Studies have begun to examine whether the treatment of insomnia in older persons may have positive secondary psychological wellbeing outcomes.

Insomnia treatments include nonpharmacological and pharmacological therapies [8, 9]. Clinical guidelines for the first line of therapy of insomnia in older persons recommend nonpharmacological interventions when appropriate and feasible [8]. For example, cognitive behavioural therapy for insomnia (CBT-I) is an effective nonpharmacological treatment for insomnia in older persons [10, 11]. Nonpharmacological techniques attempting to improve insomnia symptoms in older persons are wide-ranging and include those with a cognitive or behavioural therapy (BT) component, exercise, and mindfulness-based interventions (MBIs) [12-16]. Pharmacological treatment in older populations may increase risk of aging-related difficulties (e.g., fractures) [15] and is not recommended as first-choice insomnia therapy [14].

Older persons are at risk for poor psychological wellbeing as seen for example in the frequent experience of depression and anxiety symptoms in this population [17, 18]. Nonpharmacological treatment of insomnia has been associated with increased psychological wellbeing in some domains but not others [19]. For example, meta-analytic reviews have found that CBT-I decreases symptoms of anxiety [20] and depression, but not fatigue [21] in adults. In older persons, individual studies have reported on increased psychological

wellbeing after nonpharmacological interventions for insomnia (e.g., [22]). Yet, evidence on the psychological wellbeing outcomes of nonpharmacological interventions in older persons who experience insomnia symptoms has not been described collectively. To maximize the benefits of nonpharmacological interventions for older persons who experience insomnia symptoms, it is important to understand whether these interventions can improve particular psychological wellbeing outcomes. This systematic review and meta-analysis focuses on the following question: Can nonpharmacological interventions promote psychological wellbeing indicators in older persons who experience insomnia symptoms and what are the components of these interventions?

Methods

Search strategy

We conducted a comprehensive search of the literature in MEDLINE (PubMed), EMBASE (Ovid), CINAHL (EBSCO), PsycINFO (EBSCO), Web of Science, and the Cochrane Central Register of Controlled Trials (Wiley). Search strategies were developed in consultation with a subject librarian and customized per database. We searched for a combination of insomnia, older persons, and intervention terms in titles and abstracts using controlled vocabulary and text words in academic journal publications up to 23rd November, 2017. MEDLINE was searched from 2005 onwards to avoid overlap with Cochrane Central Register of Controlled Trials [23]. Methodology was restricted using controlled vocabulary (e.g., "clinical trials" in CINAHL) or filters (e.g., trials in Cochrane Central). For an example of one search strategy, for PsycINFO, see Appendix 1. We located additional records via searching the references of review and meta-analysis papers (e.g., [10, 13, 15, 21, 24]) and identifying papers that were familiar to the authors. In both title and abstract screening and full-text screening stages, entries were reviewed by two independent researchers and disagreements were resolved by

consensus with a third reviewer. A PRISMA flow chart is shown in Figure 1. This review was pre-registered on PROSPERO (CRD42018083629).

Inclusion and exclusion criteria

To minimize the heterogeneity of samples (thereby enabling meaningful comparisons between the studies), this review focused on physically healthy older persons (i.e., participants who were not specifically selected for a health concern [other than insomnia]). *Inclusion criteria* were: 1. All participants were ≥ 55 years of age (this cut-off is commonly used to define older adults; e.g., [25]); 2. Population was selected for insomnia symptoms or insomnia disorder; 3. At least one group received a nonpharmacological intervention for insomnia symptoms with no pharmacological elements (e.g., medication tapering); 4. There was a separate nonpharmacological control group with insomnia symptoms; 5. Pre-post comparison of intervention and control group were reported; 6. Peer-reviewed journal article that reported new experimental data in English; and 7. Reported on at least one outcome measure of psychological wellbeing. In line with our focus on psychological wellbeing outcomes that are secondary to sleep outcomes in physically healthy older persons, we use the term psychological wellbeing to include outcomes that evaluate psychological constructs and are not assessed by direct measures of sleep. These include depression and anxiety symptoms, mental health-related quality of life (HRQoL), and negative affect. While fatigue is often associated with sleep, we included fatigue as it is not a direct measure of sleep but a distinct construct that can reflect reduced psychological motivation [26]. Outcomes exclude those measured directly by sleep assessments (e.g., sleep quality scales, sleep diary items), as well as outcomes that are physical (e.g., vigilance, health), cognitive (e.g., memory), biological (e.g., inflammatory markers), global (physical and psychological combined) wellbeing/quality of life/life satisfaction, and medication use outcomes. *Exclusion criteria* were: 1. Population was selected for a neurological condition or psychiatric diagnosis or

chronic health condition; and 2. The only reported analysis compared persons selected for different characteristics (e.g., short/long sleepers, persons with/without sleep disorder) within the full sample of persons with insomnia symptoms. These exclusions were made as we wanted our results to be applicable widely to those experiencing insomnia. When papers had missing information relating to our inclusion criteria, we contacted the authors. Four papers in which age range information was not available nor made available upon request were excluded as we could not be sure they met the age criterion.

Qualitative and meta-analytic strategy

The qualitative analysis assessed the outcomes of interventions that promote a specific psychological wellbeing outcome. This analysis, based on the results reported in the original papers, was sensitive to intervention technique/component. The meta-analysis was designed to address a broad research question that relates to a range of intervention techniques with comparable methodological characteristics. Specifically, all interventions studied used nonpharmacological techniques that may affect sleep-related processes. Of the nine intervention techniques in studies that met inclusion criteria, three intervention techniques have been investigated in a single study. Five of the remaining six interventions (83%) have been investigated in 2-3 studies and one intervention has been investigated in four studies. Because of the limited number of studies per intervention and the relatively small sample sizes in individual studies, it was not feasible to consider each intervention technique in separate meta-analyses [27, 28].

We meta-analysed psychological wellbeing outcomes that were reported in ≥ 5 studies [27]. For each outcome, we calculated effect size (Cohen's *d*) using a recommended method for effect size calculation in pre-post control group designs [29]: subtracting the mean pre-post change in the comparison group from the mean pre-post change of the intervention group and dividing the outcome by the pooled pre-test standard deviation;

Hedge's [30] formula for upward bias correction in small samples was subsequently applied. All effect sizes were computed based on non-adjusted pre-treatment and post-treatment data. A positive effect size indicates higher levels of the assessed construct in the intervention group as compared to the comparison group. When data for calculation of effect sizes was not reported, we contacted the authors of the papers to retrieve this information. We excluded from the meta-analysis three studies for which no information was available on meta-analysed psychological wellbeing outcomes [31-33] and one study that had no such outcomes [34].

When calculating effect sizes, we considered multiple factors. When a study included multiple interventions that were of the same type of intervention technique (e.g., three BT interventions) [22]) we combined groups to create a single pair-wise comparison [23]. When groups comprised different types of intervention techniques, we divided the sample size for the comparison group by the number of intervention groups and included two separate pair-wise comparisons (e.g., CBT-I vs. control, and tai chi vs. control; [35]) [23]. When a study included multiple measures evaluating the same outcome construct (e.g., two depression symptoms' measures [36] or fatigue interference and fatigue severity measures [37]), we typically computed the weighted mean of both effect sizes [38]. However, in two cases where anxiety was assessed using both trait and state measures [27, 49], we computed our effect size based only on trait anxiety, which is more comparable to the constructs assessed in the other studies included in the meta-analysis. In crossover trials, we included data from the first phase of the study so that the intervention group included participants who first received the intervention and the control group included participants who first received the control intervention [39]. Cohen's criteria were used to interpret effect sizes, so that 0.20, 0.50, and 0.80 indicated small, medium and large effects, respectively [40]. Meta-analysis was

conducted on STATA 14. Considering the wide range of interventions under study, we used random-effect models that assume effect sizes underlying each study may differ [27].

Quality assessment

Quality analysis was conducted using the Revised Cochrane Risk of Bias (RoB 2.0) tool [41]. Two authors conducted the RoB assessment independently for each study and discrepancies were resolved through discussion.

Results

Twenty studies met inclusion criteria, overall reporting 25 interventions (four studies had multiple intervention groups; see Tables 1a-1e, and 2). We assigned techniques that comprised the study objective (i.e., experimental group) as intervention groups. In the meta-analysis, when a study had two groups with the same type of intervention technique, we selected the multi-component intervention as the intervention group (e.g., [42]; Tables 1a-1e). When the intervention and comparison group had a shared component, we used the distinct intervention component to label the intervention (i.e., exercise interventions with an additional education component are labelled exercise if the control group comprised an educational component). Interventions included: CBT-I (cognitive, behavioural, and education components) [31, 35, 43], BT (behavioural component(s) and no cognitive component with or without additional components) [22, 32, 34, 44-46], interventions with a cognitive therapy (CT) component [32, 42], MBIs [37, 47], exercise [48, 49], acupressure [33], supplements [50, 51], tai chi [35, 52, 53], and yoga [36] (Tables 1a-1e and 2).

Across studies, participants were at least 55 years of age and as old as 93. Sixteen of 20 (80%) studies had a majority of female participants. Eighteen of the 20 (90%) samples were of community-residents including community housing residents [42] and adult day health care participants [46]. The two institutionalized samples included one sample of nursing home residents [33] and one of long-term care facility residents [51]. Studies had different

medication use exclusion criteria (e.g., sleep/psychotropic medication use) including having no medication use exclusion criteria (n = 9) (Appendix 2). All studies reported significant improvement on at least one insomnia measure and 11 (55%) studies reported improved sleep quality as measured by the Pittsburgh Sleep Quality Index [54] (Appendix 3). Eighteen (90%) studies were randomized trials and two were non-randomized. The duration of interventions ranged from 1 week to 12 months delivered over 2-104 sessions (see Appendix 4 for interventions' format characteristics).

Qualitative Analysis of Psychological Wellbeing Outcomes

The most commonly assessed psychological wellbeing outcomes were symptoms of depression (n = 16), anxiety (n = 11), mental HRQoL (n = 5) and fatigue (n = 5). Other outcomes (e.g., anger) were largely reported in individual studies. Table 2 presents a qualitative analysis of interventions' technique, components, and outcomes among older persons who experience insomnia symptoms based on the resultspresented in the original papers.

Depression symptoms

Sixteen studies examined depression symptoms' outcomes (Table 2), overall reporting 20 interventions. Ten studies (62.5%) reported reductions ($p \leq .05$) in depression symptoms following intervention [22, 35-37, 44, 45, 47-49, 51] and six did not [31, 32, 42, 43, 46, 50]. Eleven interventions led to reductions in depression symptoms. These included exercise, MBIs, BT, yoga, CBT-I, tai chi, and supplement. The six studies that did not report improvement included interventions involving CBT-I, BT, CT, and supplements (Table 2).

Amongst the different interventions, those that reduced depression symptoms included MBIs (two studies; [37, 47]), moderate exercise (two studies; [48, 49]), a single-component sleep restriction behavioural intervention with a sleep education component (one study; [22]), yoga (one study; [36]), tai chi (one study; [35]), and food supplements

containing melatonin, magnesium, and zinc (one study; [51]) (Table 2). Reports largely support the potential of BT interventions with sleep restriction and a stimulus control and/or education components to reduce depression symptoms [22, 44, 45]. Specifically, sleep restriction, stimulus control plus education significantly reduced depression symptoms in comparison to an education control in two studies [44, 45]. In a further study, sleep restriction plus education significantly reduced depression symptoms but sleep restriction, stimulus control plus education did not [22] (Table 2). Three studies examined the capacity of CBT-I interventions with a stimulus control component to reduce depression symptoms [31, 35, 43]. Of these interventions, CBT-I interventions that included a mood enhancement component reduced depression symptoms [35] while CBT-I interventions that included a sleep restriction component did not [31, 43] (Table 2).

Anxiety symptoms

Eleven studies examined anxiety symptoms as an outcome (Table 2), overall reporting 14 interventions. Of these, two studies (18%) reported significant reductions in anxiety symptoms following intervention [22, 42] and 10 did not [22, 31, 32, 36, 37, 44, 45, 47, 49, 50]. Interventions that led to significant reductions in anxiety symptoms involved music relaxation with an additional CT (mental imagery) component [42] and behavioural sleep restriction (with an additional education component) that reduced state, but not trait, anxiety [22]. The ten studies that did not report significant reductions in anxiety symptoms included MBIs, exercise, BT, CT, CBT-I, yoga, and supplements interventions (Table 2).

Mental health-related quality of life

The assessment of HRQoL focuses on the impact of disease or illness on aspects of mental and physical function [55]. In line with this review's focus on psychological wellbeing outcomes, we examined only mental HRQoL outcomes. Nine studies examined HRQoL as an outcome. Of these studies, five studies that reported mental component scores [43, 46, 51-53]

were included in this analysis and four studies that did not [33, 36, 44, 48] were excluded. Of the five studies that reported mental HRQoL component outcomes (Table 2), one study (20%) reported significant improvements in mental HRQoL after a tai chi intervention in comparison to a placebo condition [52]. Four studies involving CBT-I, BT, tai chi, and supplements interventions reported no significant improvements [43, 46, 51, 53] (Table 2).

Fatigue symptoms

Five studies examined fatigue symptoms as an outcome (Table 2). Four studies (80%) reported significant reductions in fatigue symptoms after an intervention [35-37, 46] and one study of a supplements intervention did not [50]. The four studies that reported significant reductions in fatigue symptoms included five interventions involving BT, CBT-I, MBI, tai chi, and yoga (2).

Other psychological wellbeing outcomes

Four studies reported on other psychological wellbeing outcomes (when outcomes on a measure's subscales were reported, we refer to the subscales' constructs for greater specificity) (Table 1e). These included stress [36, 37], tension, anger [36], mindfulness [37], global mood (including evaluation of symptoms of a range of constructs such as anxiety, depression, anger, fatigue, and vigour) [31], and life satisfaction [34]. A yoga intervention with yogic postures and meditation exercise components significantly reduced stress in comparison to waitlist controls [36] and MBI increased mindfulness in comparison to education control group [37].

Meta-Analysis

Tables 1a-1e present the characteristics of studies by outcome (i.e., depression symptoms [1a], anxiety [1b], HRQoL [1c], fatigue [1d], and other [1e]) and the effect sizes and group sizes used for their calculation per study. Measurements of psychological wellbeing outcomes per study are shown in Appendix 5. The overall effects of interventions on psychological

wellbeing outcomes are presented in Table 3.

Meta-analysis findings showed that the weighted mean effect sizes of interventions on symptoms of depression, anxiety, and fatigue were small-medium and reliable (confidence interval did not include zero). The weighted mean effect size of mental HRQoL was close to zero and was not reliable. Prior to analysis, an inspection of effect sizes' distribution revealed two very large effect sizes ($d \geq 1.4$). We Winsorized these effect sizes before analysis (i.e., replaced with the next highest effect size) [38] to ensure our overall estimates were robust. Winsorizing one fatigue effect size reduced the overall mean from medium to small-medium but did not affect its reliability. Winsorizing one mental HRQoL effect size reduced an overall small-medium positive effect size to a very small negative effect size and there remained a lack of reliability. Across psychological wellbeing outcomes, heterogeneity (Q) was not significant and I^2 values were low, suggesting that the effect size of nonpharmacological interventions was not moderated by study characteristics. To test for publication bias, we visually inspected the funnel plots of effect sizes based on ≥ 9 studies (i.e., depression and anxiety) [23]. The funnel plots for these outcomes were relatively symmetrical and Egger's regression was nonsignificant for both symptoms of depression (β = -1.35, p = .21) and anxiety (β = 0.13, p = .88) indicating no evidence of a relationship between study size and effect size.

Quality Assessment

Results from the quality assessment are presented in Table 4. Overall RoB ratings were low (n = 6), some concerns (n = 7), or high (n = 7). Subgroup analyses showed that overall effect sizes for symptoms of depression, anxiety, and fatigue maintained small-to-medium size when studies coded as high RoB were excluded (d_{range}: -0.30 - -.41; Appendix 6), but that the confidence interval for fatigue now crossed zero.

Discussion

This systematic review examined the psychological wellbeing outcomes of nonpharmacological interventions employed to improve insomnia symptoms in physically healthy older persons. It was found that nonpharmacological interventions for older persons who experience insomnia symptoms reduced depression and fatigue symptoms in most of the studies that included these outcomes. In a meta-analysis of the effects of different nonpharmacological interventions on older persons' psychological wellbeing, small-medium weighted mean effects indicating reductions in symptoms of depression, anxiety, and fatigue were found. A detailed discussion of our main findings with regards to the impact of MBIs, BT, and exercise on depression symptoms in older adults as well as of meta-analytic findings follows.

Mixed results mean that it is too early to draw strong conclusions per intervention technique. Nonetheless, in our qualitative analysis, we found that evidence from multiple studies supports the potential of MBIs to reduce depression symptoms in older persons with insomnia symptoms. Of note, there was no evidence of nonsignificant findings. These findings support the favourable effects of mindfulness-based therapies [56, 57] on depression in older persons and corroborate evidence on the psychological wellbeing benefits of MBIs in adults [58, 59] and in older persons [60] including older samples with clinical depression [61]. MBIs were found to improve insomnia symptoms in older persons in two (out of two) studies included in this review (Appendix 3) and to reduce insomnia severity in populations that experience insomnia symptoms [16]. While the exact mechanisms for the effects of MBIs on insomnia symptoms are yet to be established, hypotheses include reducing cognitive rumination, unpleasant emotional states, physiological arousal, or attentional bias [16]. In line with previous meta-analysis findings [62], current results are consistent with the possibility that mechanisms that facilitate reductions in depression symptoms (e.g., decreased cognitive and emotional reactivity, repetitive negative thinking) [62] may further underlie reductions in

insomnia symptoms following MBIs. Nonetheless, considering the bidirectional relationship between insomnia and depression in older persons [63], future research on the trajectory of effects following MBIs is needed. Taken together, current and previous evidence suggest that MBIs have the potential to reduce insomnia symptoms and enhance psychological wellbeing in older persons. This may pertain to MBIs as standalone interventions or as one component in a multicomponent intervention. Indeed, emerging evidence supports the efficacy of interventions that combine mindfulness components with BT (e.g., mindfulness-based therapy for insomnia (MBT-I)) or CT components (e.g., mindfulness-based cognitive therapy) [64, 65]. For example, MBT-I have been found to improve insomnia symptoms and sleep-related cognitions in adults [66]. Others have found that insomnia improvements obtained following CBT-I increased following further treatment involving mindfulness exercises [67].

Our qualitative findings suggest that BT interventions involving sleep restriction and a stimulus control and/or education component show promise in improving depression symptoms in older persons with insomnia symptoms [22, 44, 45] – although the effective component is difficult to ascertain in multicomponent treatments. Sleep restriction therapy - a mild form of sleep deprivation that increases sleep consolidation and can reduce insomnia symptoms [8, 9] - has potent anti-depressant effects [68]. In addition, current findings show that when sleep restriction interventions had an additional CT component, no significant improvements in depression symptoms were found [31, 43]. Future research is needed to further replicate this finding, and if it proves robust to better understand why sleep restriction might reduce depression symptoms in BT but not CBT-I interventions, particularly in view of the comparability of BT and CBT-I posttreatment effects on nighttime sleep [69] and recommendations to use CBT-I as first line of therapy for chronic insomnia disorder [70].

Current qualitative findings suggest that moderate exercise can potentially reduce

depression symptoms in older persons who experience insomnia symptoms (although one study was reported as marginally significant;our effect size calculations showed CIs spanned zero). Exercise has been found to improve mental health in older adults [71] and sleep in adults [72]. Multiple studies have also reported on the positive sleep effects of moderate exercise in older persons with sleep complaints [73] (Appendix 3). The proposed mechanisms through which exercise impacts insomnia symptoms include antidepressant effects, anxiety reduction, and restorative processes [74]. Current findings are in line with the possibility that mechanisms that operate through reduction of depression symptoms may underlie the effects of exercise on sleep outcomes in older persons. Nonetheless, as aforementioned, the trajectory of effects [63] is a direction for future research.

Meta-analysis findings showed a small-medium reduction in depression symptoms across studies. This finding is in line with current qualitative findings, overall highlighting the potential of various interventions including MBIs to reduce depression symptoms. In addition, our meta-analysis showed a small-medium reduction in anxiety symptoms across studies. This finding enhances our qualitative findings on the impact of nonpharmacological interventions on anxiety; while this effect was typically non-significant within individual studies, in aggregate, the data support a small but significant reduction in anxiety. This is in line with the findings of a meta-analysis of CBT-I interventions in samples with concurrent insomnia and anxiety symptoms [20]. Current qualitative and quantitative findings on mental HRQoL outcomes are in accord, overall showing that nonpharmacological interventions for insomnia largely do not engender improvement in mental HRQoL in older persons. Finally, the current meta-analysis findings showed a small-medium reduction in fatigue symptoms across studies. This was supported by the qualitative analysis, overall showing that a range of nonpharmacological interventions (evidenced by a single study each) can reduce fatigue

symptoms in older persons with insomnia symptoms. Future research is needed to establish the impact of these interventions on subclinical and clinical fatigue in older persons.

This systematic review is not without limitations. Nearly two thirds of the studies in this review (65%) did not exclude participants who regularly used medications (Appendix 2). Accordingly, we did not have medication use exclusion criteria as that would have significantly limited our ability to address our research question. However, it is possible that individual differences in medication use contribute to older persons' intervention responsiveness [75] and that reviews that focus on this variable may evidence a different pattern of findings. The use of medication that has central nervous system effects may affect the psychological wellbeing outcomes obtained in individual studies in this review. For example, it is possible that in studies that included participants who use medications, findings on psychological wellbeing benefits may reflect an independent effect of the intervention or a combined effect of the intervention and medication use. The question of whether nonpharmacological interventions in older persons with insomnia symptoms improve psychological wellbeing independently of medication use is an important one that should be considered in designing future studies and, when evidence accumulates, in future meta-analyses.

A further potential limitation of this review stems in the fact that poor sleep is a symptom of certain depression and anxiety disorders [76]. Accordingly, the assessment of depression and anxiety often includes items that evaluate insomnia symptoms. Indeed, this was often the case for psychological wellbeing measures that were used in studies in this review (e.g., Beck depression inventory; [77]) (Appendix 5). While it is possible that a reduction in depression/anxiety scores in studies in this review could simply reflect improved sleep quality, multiple studies in this review obtained these reductions using psychological wellbeing measures that do not include sleep items (e.g., the geriatric depression scale; [78]).

Another limitation includes the fact that we excluded non-psychological (e.g., physical, biological) wellbeing outcomes. Literature focusing on these outcomes for older persons with insomnia symptoms is considerable and merits a complementary review.

Most studies including MBIs and exercise studies were not coded as low RoB. However, it is noteworthy that the RoB 2.0 tool provides a very rigorous methodology (with a tendency to flag possible bias when no information is available). For example, its guidelines recognize that most trials will be rated with concerns of selection of reported results given the often limited availability of analysis intentions [41]. Attesting the stability of the overall effect sizes obtained in our meta-analysis, these remained small-medium when excluding studies coded as high RoB.

When considering the effect sizes reported in the meta-analysis, it is necessary to consider a potential ceiling effect. Specifically, this review focused on older persons who were not selected because they had clinical diagnoses (e.g., major depression disorder). Baseline psychological wellbeing levels can therefore only be improved to a limited extent in this population. Nonetheless, current meta-analysis findings show small-medium weighted mean effect sizes that indicate enhanced psychological wellbeing. Furthermore, these exceeded the overall small effect size of physical activity on wellbeing in older persons [79]. Thus, the current findings support the notion that improving psychological wellbeing should be considered a valuable objective of nonpharmacological interventions for older persons with insomnia symptoms [80]. This is particularly the case considering the long-term sleep benefits associated with psychological wellbeing gains obtained following nonpharmacological interventions in non-clinical older populations [49]. Meta-analysis findings on fatigue and mental HRQoL may have limited accuracy due to the low number of studies included [27]. Nonetheless, the validity of the findings is enhanced by the findings of the qualitative review. In some studies, significant improvements in the intervention group

were reported in the original paper but the CIs of our effect size calculations crossed zero. These discrepancies reflect different calculations and in some cases different samples sizes that reflect our meta-analytic approach and highlight the need for caution in interpreting the qualitative findings. In line with previous meta-analyses of nonpharmacological interventions that target sleep [81], the current meta-analysis combined a range of intervention techniques that have common features (e.g., nonpharmacological). Finally, the psychological wellbeing benefits of MBIs notwithstanding, MBIs may lead to adverse effects (e.g., negative reactions) in some cases and may be less suitable for persons who are unmotivated and reluctant to engage in mindfulness practices [82].

Conclusion

The current meta-analysis findings suggest that nonpharmacological interventions that target insomnia symptoms can potentially improve the psychological wellbeing of older persons, particularly symptoms of depression, fatigue, and anxiety, but may not improve mental HRQoL. While it is premature to draw strong conclusions, qualitative analyses suggest that MBIs, moderate exercise, and sleep restriction as a BT component can potentially reduce depression symptoms in older persons with insomnia symptoms. These interventions have been shown to improve insomnia symptoms in older persons and show promise in treating insomnia and comorbid depression symptoms in older persons. Considering the need to identify effective treatment programmes for older persons with comorbid insomnia and depression [80], studies on the impact of MBIs in particular in this population represent a valuable direction for future research. We are hopeful that the findings of this review will inform researchers and health practitioners on the currently available data on the benefits of nonpharmacological interventions among older persons who experience insomnia symptoms, which span different aspects of psychological wellbeing.

Practice Points

1. Qualitative analyses suggest that mindfulness-based interventions have the potential for improving psychological wellbeing in older persons with insomnia symptoms.

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3. Qualitative analyses suggest that sleep restriction as a component in behavioural interventions shows promise in improving depression symptoms in older persons with insomnia symptoms.

Research Agenda

To improve insomnia and psychological wellbeing outcomes in older persons, randomized controlled trials are needed to confirm the effectiveness of:

1. Mindfulness-based interventions in older persons with comorbid insomnia and clinical and subclinical depression;
2. Moderate exercise in older persons with comorbid insomnia and clinical and subclinical depression;
3. Nonpharmacological interventions that have shown promise in reducing fatigue in older persons with comorbid insomnia and clinical and subclinical fatigue.

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Table 1a. Characteristics of studies with depression symptoms' outcomes (*n* = 16)

Study	Sample	Age,[a] y	Gender (% F)	Randomization	Intervention technique[b] (comparison group)	Group size, *n*		Effect size Depression symptoms
						All groups	Groups used for effect size calculation[c]	*d* (95% CI)
Included in meta-analysis								
Alessi et al., 2016 [43]	CD	60-91	3	R	CBT-I (EDU)	I = 106 C = 53		-0.01 (-0.34 to 0.32)
Black et al., 2015 [37]	CD	55+	67	R	MIND (EDU)	I = 24 C = 25		-0.75 (-1.33 to -0.17)
Buman et al., 2011 [49]	CD	55-79	66	R	EXE + EDU (EDU)	I = 36 C = 30		-0.49 (-0.98 to 0.01)
Buysse et al. 2011 [44]	CD	60-87	68	R	BT + EDU (EDU)	I = 39 C = 40		-0.76 (-1.22 to -0.3)

Epstein et al., 2012 [22]	CD	55-92	64	R	$I_{1,2,3}$: BT + EDU (WL)	I_1 = 44 I_2 = 44 I_3= 41 C = 50	I = 108 C = 39	-0.09 (-0.46 to 0.27)
Germain et al., 2006 [45]	CD	60+	71	R	BT + EDU (EDU)	I = 17 C = 18		-0.93 (-1.63 to -0.24)
Halpern et al., 2014 [36]	CD	60+	82	NR	Yoga (WL)	I = 59 C = 31	I = 51 C = 21	-0.01 (-0.37 to 0.35)
Irwin et al., 2014 [35]	CD	55-85	72	R	I_1: CBT-I I_2: TAI (EDU)	I_1 = 50 I_2 = 48 C = 25		CBT-I vs. EDU
							I = 50 C = 13	-0.28 (-0.89 to 0.33)
								TAI vs. EDU
							I = 48 C = 12	-0.17 (-0.81 to 0.46)
Martin et al., 2017 [46]	CD	60+	7	R	BT + EDU (EDU)	I = 21 C = 21		-0.19 (-0.79 to 0.42)

Pigeon et al., 2010 [50][e]	CD	65+	47	R	SUP (PLAC)	I = 15 C = 15	I = 8 C = 7	-0.04 (-1.06 to 0.97)
Reid et al. 2010 [48]	CD	55+	94	R	EXE + EDU (ACT+ EDU)	I = 10 C = 7		-0.87 (-1.88 to 0.14)
Rondanelli et al., 2011 [51]	INST	70+	63	NR	SUP (PLAC)	I = 22 C = 21		-0.73 (-1.34 to -0.1)
Zhang et al., 2015 [47]	CD	75+	42	R	MIND (WL)	I = 30 C = 30		-0.73 (-1.25 to -0.2)
Ziv et al., 2008 [42][e]	CD	67-93	73	R	RLX_{music} + CT[f] ($RLX_{muscular}$)	I = 15 C = 15	I = 8 C = 7	0 (-1.01 to 1.02)
Not included in meta-analysis								
Morin & Azrin, 1988 [32]	CD	55+	63	R	I_1: BT I_2: CT (WL)	I_1 = 9 I_2 = 8 C = 10	No available depression symptoms' data	
Morin et al. 1993 [31]	CD	60+	71	R	CBT-I (WL)	I = 12 C = 12	No available depression symptoms' data	

Table 1b. Characteristics of studies with anxiety outcomes (*n* = 11)

Study	Sample	Age,[a] y	Gender (% F)	Randomization	Intervention technique[b] (comparison group)	Group size, *n*		Effect size anxiety
						All groups	Groups used for effect size calculation[c]	*d* (95% CI)
Included in meta-analysis								
Black et al., 2015 [37]	CD	55+	67	R	MIND (EDU)	I = 24 C = 25		-0.02 (-0.58 to 0.54)
Buman et al., 2011 [49]	CD	55-79	66	R	EXE + EDU (EDU)	I = 36 C = 30		-0.22 (-0.7 to 0.27)
Buysse et al. 2011 [44]	CD	60-87	68	R	BT + EDU (EDU)	I = 39 C = 40		-0.44 (-0.89 to 0.01)
Epstein et al., 2012 [22]	CD	55-92	64	R	$I_{1,2,3}$: BT + EDU (WL)	I_1 = 44 I_2 = 44 I_3= 41 C = 50	I = 108 C = 39	-0.17 (-0.54 to 0.2)

Germain et al., 2006 [45]	CD	60+	71	R	BT + EDU (EDU)	I = 17 C = 18		-0.65 (-1.33 to 0.03)
Halpern et al., 2014 [36]	CD	60+	82	NR	Yoga (WL)	I = 59 C = 31	I = 56 C = 22	-0.13 (-0.62 to 0.36)
Pigeon et al., 2010 [50][e]	CD	65+	47	R	SUP (PLAC)	I = 15 C = 15	I = 8 C = 7	-0.07 (-1.08 to 0.94)
Zhang et al., 2015 [47]	CD	75+	42	R	MIND (WL)	I = 30 C = 30		-0.42 (-0.93 to 0.09)
Ziv et al., 2008 [42][e]	CD	67-93	73	R	RLX_{music} + CT[f] ($RLX_{muscular}$)	I = 15 C = 15	I = 8 C = 7	-0.03 (-1.05 to 0.98)

Not included in meta-analysis

Morin & Azrin, 1988 [32]	CD	55+	63	R	I_1: BT I_2: CT (WL)	I_1 = 9 I_2 = 8 C = 10	No available anxiety data
Morin et al. 1993 [31]	CD	60+	71	R	CBT-I (WL)	I = 12 C = 12	No available anxiety data

Table 1c. Characteristics of studies with health-related quality of life outcomes (*n* = 9)

Study	Sample	Age,[a] y	Gender (% F)	Randomization	Intervention technique[b] (comparison group)	Group size, *n*		Effect size mental health-related quality of life
						All groups	Groups used for effect size calculation[c]	*d* (95% CI)
Included in meta-analysis								
Alessi et al., 2016 [43]	CD	60-91	3	R	CBT-I (EDU)	I = 106 C = 53		-0.25 (-0.58 to 0.08)
Chan et al., 2016 [52]	CD[d]	60+	85	R	TAI (PLAC)	I = 27 C = 25		1.88[†] (1.22 to 2.53)
Li et al., 2004 [53]	CD	60-92	81	R	TAI (ACT)	I = 62 C = 56		-0.02 (-0.38 to 0.34)
Martin et al., 2017 [46]	CD	60+	7	R	BT + EDU (EDU)	I = 21 C = 21		0.25 (-0.36 to 0.86)
Rondanelli et al., 2011 [51]	INST	70+	63	NR	SUP (PLAC)	I = 22 C = 21		0.2 (-0.4 to 0.8)

Not included in meta-analysis

Buysse et al. 2011 [44]	CD	60-87	68	R	BT + EDU (EDU)	I = 39 C = 40	No available mental component data
Halpern et al., 2014 [36]	CD	60+	82	NR	Yoga (WL)	I = 59 C = 31	No available mental component data
Lai et al., 2017 [33]	INST	65+	68	R	ACU (PLAC)	I = 31 C = 31	No available mental component data
Reid et al. 2010 [48]	CD	55+	94	R	EXE + EDU (ACT + EDU)	I = 10 C = 7	No available mental component data

Table 1d. Characteristics of studies with fatigue outcomes (n = 5)

Study	Sample	Age,[a] y	Gender (% F)	Randomization	Intervention technique[b] (comparison group)	Group size, *n*		Effect size fatigue
						All groups	Groups used for effect size calculation[c]	*d* (95% CI)
Included in meta-analysis								
Black et al., 2015 [37]	CD	55+	67	R	MIND (EDU)	I = 24 C = 25		-1.40[†] (-1.94 to -0.86)
Halpern et al., 2014 [36]	CD	60+	82	NR	Yoga (WL)	I = 52 C = 22		-0.39 (-0.9 to 0.11)
Irwin et al., 2014 [35]	CD	55-85	72	R	I_1: CBT-I I_2: TAI (EDU)	I_1 = 50 I_2 = 48 C = 25	CBT-I vs. EDU I = 50 C = 13	-0.29 (-0.9 to 0.33)
							TAI vs. EDU I = 48 C = 12	-0.22 (-0.85 to 0.42)

Martin et al., 2017 [46]	CD	60+	7	R	BT + EDU (EDU)	I = 21 C = 21		-0.47 (-1.08 to 0.14)
Pigeon et al., 2010 [50][e]	CD	65+	47	R	SUP (PLAC)	I = 15 C = 15	I = 8 C = 7	-0.05 (-1.06 to 0.97)

Table 1e. Characteristics of studies with other outcomes (*n* = 4)

Study	Sample	Age,[a] y	Gender (% F)	Randomization	Intervention technique[b] (comparison group)	Group size, *n*	Psychological wellbeing outcome (other)
Black et al., 2015 [37]	CD	55+	67	R	MIND (EDU)	I = 24 C = 25	stress, mindfulness
Halpern et al., 2014 [36]	CD	60+	82	NR	Yoga (WL)	I = 59 C = 31	anger, stress, tension
Morin et al. 1993 [31]	CD	60+	71	R	CBT-I (WL)	I = 12 C = 12	mood global
Pallesen et al., 2003 [34]	CD	60-84	84	R	I_1: BT + EDU I_2: RLX + EDU (WL)	I_1 = 15 I_2 = 14 C = 26	life satisfaction

Notes. Education classification denotes having a sleep education element. Where effect sizes are based upon multiple outcome measures with different Ns, the reported Ns have been averaged across these outcomes. In table 1e, the label "other" refers to outcomes that are not specified in Table 1a-1d and are not included in the meta-analysis.

[a] Where only the bottom of the age range is listed, the top of the age range was not available

[b] In studies with multiple intervention groups, interventions are numbered consecutively and the intervention technique is followed by number of participants

in the respective intervention group. For example, in the study by Irwin et al. (2014), one group with 50 participants received a CBT-I intervention, a second group with 48 participants received a Tai Chi intervention, and the comparison group with 25 participants received an education intervention.
[c] Specified only for studies in which the size or number of groups differed from those reported in the preceding "All groups" column
[d] Sample selected for cognitive impairment
[e] Groups' sizes used for effect size calculation represent two phases in a crossover trial
[f] In the music relaxation intervention, participants were asked to relax and to imagine a scenario. Using mental imagery is one key characteristic of CT [32]. This intervention is therefore categorized as a music relaxation intervention with a CT component.
[†] Effect size was Winsorized in the meta-analysis.
ACT= activity; ANX = anxiety symptoms; BT = behavioural therapy; C = comparison group; CD = community-dwellers; CT = cognitive therapy, CI = confidence interval; EDU = education; EXE=exercise; F = female; G = group; I = intervention; IND = individualized, INST = Institutionalized; N/A = not applicable; NR = not randomized; PLAC= placebo; R = randomized; RLX = relaxation; SA = self-administered; SUP = supplement; TAI = tai chi; WL = waitlist

Table 2. Interventions' technique, components, and outcomes among older persons who experience insomnia symptoms based on the results presented in the papers

Intervention Technique	Psychological wellbeing outcomes				Comparison group	Study
	Depression symptoms	Anxiety symptoms	Mental health-related quality of life	Fatigue symptoms		
	Intervention components[†]					
BT	**SRT + SCT + EDU**	SRT + SCT + EDU			EDU	Buysse et al., 2011 [44]
	SRT + EDU	**SRT + EDU**[a, b]			WL	Epstein et al., 2012 [22]
	SRT + EDU	SRT + EDU			SCT + EDU	
	SRT + EDU	SRT + EDU			SRT + SCT + EDU	
	SCT + EDU	SCT + EDU			WL	
	SCT + EDU	SCT + EDU			SRT + EDU	
	SCT + EDU	SCT + EDU			SRT + SCT + EDU	
	SRT + SCT + EDU	SRT + SCT + EDU			WL	
	SRT + SCT + EDU	SRT + SCT + EDU			SRT + EDU	

	SRT + SCT + EDU	SRT + SCT + EDU			SCT + EDU	
	SRT + SCT + EDU	SRT + SCT + EDU			EDU	Germain et al., 2006 [45]
	SCT-M + SC + EDU + prevention and coping strategies		SCT-M + SC + EDU + prevention and coping strategies	**SCT-M + SC + EDU + prevention and coping strategies**	EDU	Martin et al., 2017 [46]
	SCT	SCT			WL	Morin & Azrin, 1988 [32]
CBT-I	SRT + SCT + CT + EDU + relapse prevention		SRT + SCT + CT + EDU + relapse prevention		EDU	Alessi et al., 2016 [43]
	SCT + BEHAV + CR + EDU + SKILL			**SCT + BEHAV + CR + EDU + SKILL**	TAI	Irwin et al., 2014 [35]
	SCT + BEHAV + CR + EDU + SKILL			**SCT + BEHAV + CR + EDU + SKILL**	EDU	
	SRT + SCT + CR + EDU	SRT + SCT + CR + EDU			WL	Morin et al., 1993 [31]

CT	Imagery training	Imagery training		WL	Morin & Azrin, 1988 [32]
EXE	**Moderate-intensity exercise + EDU**	Moderate-intensity exercise + EDU[a]		EDU	Buman et al., 2011 [49]
	Aerobic exercise + EDU			ACT + EDU	Reid et al., 2010 [48]
MIND	**Mindfulness practices**	Mindfulness practices	**Mindfulness practices**[c]	EDU	Black et al., 2015 [37]
	Mindfulness practices	Mindfulness practices		WL	Zhang et al., 2015 [47]
RLX	Music relaxation exercise + mental imagery	**Music relaxation exercise + mental imagery**		Muscular relaxation	Ziv et al., 2008 [42]
SUP	Beverage: tart cherry juice	Beverage: tart cherry juice	Beverage: tart cherry juice	PLAC	Pigeon et al., 2010 [50]

	Food supplement: melatonin, magnesium, and zinc	Food supplement: melatonin, magnesium, and zinc		PLAC	Rondanelli et al., 2011 [51]
TAI		**Tai Chi movement exercises**		PLAC	Chan et al., 2016 [52]
	Tai Chi movement exercises		**Tai Chi movement exercises**	EDU	Irwin et al., 2014 [35]
	Tai Chi movement exercises		Tai Chi movement exercises	CBT-I	
		Tai Chi movement and breathing exercises		ACT	Li et al., 2004 [53]
Yoga	**Yogic postures + meditation exercises**	Yogic postures + meditation exercises	**Yogic postures + meditation exercises**	WL	Halpern et al., 2014 [36]

Note. Education classification denotes having a sleep education element.

† Under "intervention components" are listed all comparisons per intervention technique in a specific study by outcome. Each cell represents a comparison between the intervention group and the respective comparison group (listed in a separate column). Based on the results presented in the papers, improved outcomes ($p \leq .05$) in intervention group are noted in bold. For example, in the study by Zhang et al., 2015 [47], the intervention group showed significantly reduced depression symptoms but did not show significantly reduced anxiety symptoms (in comparison to waitlist). All comparisons are based on pre-treatment and/or post-treatment data.

ACT = activity; BEHAV = behavioural mood enhancement; BT = behavioural therapy; CBT-I = cognitive behavioural therapy for insomnia; CR = cognitive restructuring; CT = cognitive therapy; EDU = education; EXE=exercise; PLAC= placebo; RLX = relaxation; SC= sleep compression; SCT= stimulus control

therapy; SCT-M = stimulus control therapy – modified; SKILL = skills consolidation and adherence training; SRT = sleep restriction therapy; SUP = supplement; TAI = tai chi; WL = waitlist

[a] This study included two measures of anxiety: state-anxiety and trait-anxiety.

[b] The only significant improvement was found on state anxiety between SRT+EDU in comparison to WL. All other comparisons in this study reported under anxiety refer to both measures.

[c] Fatigue outcomes in this study refer to two fatigue subscales: fatigue interference and fatigue severity.

Table 3. Overall effects of interventions on psychological wellbeing outcomes

Outcome	*k*	*d* (95% CI)	*Q*	I^2 (95% CI)
Depression symptoms	15	-0.38 (-0.56 to -0.20)	21.58	35.1% (0% to 65.0%)
Anxiety symptoms	9	-0.25 (-0.43 to -0.08)	3.82	0% (0% to 26.3%)
Mental health-related quality of life	5	-.01 (-.21 to 0.19)	4.07	1.7% (0% to 79.6%)
Fatigue symptoms	6	-0.35 (-0.60 to -0.10)	0.85	0% (0% to 0%)

Note. All *Q* values were not significant, $p > .05$, indicating effect size heterogeneity is no more than would be expected by chance.
I^2 is the proportion of observed variance attributable to variation across studies.
k = number of effect sizes, CI = Confidence Interval

Table 4. Risk of bias assessment (N = 20)

	Risk of bias in					
	Randomization process	Deviation from intended intervention	Missing outcome data	Measurement of the outcome	Selection of the reported results	Overall
Alessi et al., 2016 [43]	Low	Low	Low	Low	Low	Low
Black et al., 2015 [37]	Low	Low	High	Low	Some concerns	High
Buman et al., 2011 [49]	Some concerns	Low	Low	Low	Some concerns	Some concerns
Buysse et al. 2011 [44]	Low	Some concerns	Low	Low	Low	Some concerns
Chan et al., 2016 [52]	Low	Low	Some concerns	Low	Low	Some concerns
Epstein et al., 2012 [22]	Low	Low	High	High	Some concern	High
Germain et al., 2006 [45]	Low	Low	Low	Low	Low	Low
Halpern et al., 2014 [36]	High	High	High	Some concerns	High	High
Irwin et al., 2014 [35]	Low	Low	Low	Low	Some concern	Some concerns
Lai et al., 2017 [33]	High	Low	Low	Low	Some concerns	High
Li et al., 2004 [53]	Low	Low	Low	Low	Low	Low

Martin et al., 2017 [46]	Low	Low	Low	Low	Low	Low
Morin & Azrin, 1988 [32]	Some concerns	Low	Low	Some concerns	Low	Some concerns
Morin et al. 1993 [31]	Low	Low	Low	High	Low	High
Pallesen et al., 2003 [34]	Some concerns	Low	Low	High	Low	High
Pigeon et al., 2010 [50]	Low	Low	Low	Low	Low	Low
Reid et al. 2010 [48]	Some concerns	High	High	High	Some concern	High
Rondanelli et al., 2011 [51]	Low	Low	Low	Low	Low	Low
Zhang et al., 2015 [47]	Low	Low	Low	Low	Some concern	Some concerns
Ziv et al., 2008 [42]	Some concerns	Low	Some concerns	Low	Low	Some concerns

Note. Please note that quality assessment was conducted using the Revised Cochrane Risk of Bias (RoB 2.0) tool [41], which provides a structured framework to assess domain-specific concerns that are likely to affect the capacity to reach reliable conclusions based on the study. This tool provides a very rigorous methodology (with a tendency to flag possible bias when no information is available). For example, according to the tool guidelines, RoB is likely to increase in: trials with self-reported outcomes in which participants are not blinded to intervention status; trials for which over 10% of continuous outcomes data is missing in different proportions in compared groups or due to different reasons in compared groups; and trials for which analysis intentions are not available or reported in limited detail.